

# **Staying ahead of the game: A framework for effective aquaculture decision-making**

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**This thesis is submitted in fulfilment for the requirements for a conjoint degree of PhD at the University of Tasmania and the University of St Andrews, February 2016**



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The research associated with this thesis abides by international and Australian codes on human and animal experimentation, the guidelines by the Australian Government's Office of Gene Technology Regulator and the rulings of the Safety, Ethics and Institutional Biosafety Committees of the University. Ethics approval was granted under the University of Tasmania's human ethics (minimal risk) research procedure: Ethics approval Reference No. H14069.

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## ACKNOWLEDGEMENTS

First and foremost I would like to thank my supervisors: Dr Nicholas Elliott (CSIRO) and Dr Catriona Macleod (UTas) in Tasmania who had the initial vision for the project and the drive, energy and enthusiasm to bring it to life and to Dr Mark James and Professor David Paterson of the University of St Andrews for their helpful conversations, invaluable guidance and advice. I am also highly appreciative to Linda Sams at Tassal in Tasmania, and Steve Bracken of Marine Harvest Scotland, for their wholehearted support and for passionately galvanising their teams into action when required.

Funding for the research was embedded with the Australian Seafood Cooperative Research Centre's (CRC) future aquaculture production programme (Project 2011-735), and provided by the Tasmanian Salmonid Growers Association (TSGA). I am extremely grateful to these organisations for their financial support.

Key in the success of the research was the active engagement of the international aquaculture community. The information and support that they provided was invaluable in ground-truthing the research findings and assessing the implications for the Tasmanian Atlantic salmon industry. Particular thanks must go to Alistair Struthers and Gregor Reid (Fisheries & Oceans) and Pamela Parker (Atlantic Fish Farmers Association) in Canada, Hamish Rodgers (Vet-Aqua International) Ireland, and Østen Jensen of SINTEF Fisheries and Aquaculture, Norway, whose individual contributions were instrumental in facilitating a productive and 'stress-free' fieldwork experience; to Steven Summerfelt (Freshwater Institute, USA) and Thue Holm (Atlantic Sapphire, Denmark) who took me up the RAS learning curve; and to Craig Selkirk, Alan Watt and Richard Miller of the Tassal Group in Australia and Alistair Duff (Marine Harvest Scotland) whose individual contributions were instrumental in 'sanity checking' the technical screening and validating the economic analysis.

Special thanks must go to my family, natural and extended, in both halves of the world, who supported and encouraged me through all the challenging times. To Dr Jennifer Cobcroft for her 'un-official supervisory advice' over many Hops-Night beers at the New Sydney Pub and for looking after my faithful 1985 Volvo 240 station-wagon 'Julia' when I was away; to Jane my wife who patiently watched her husband tour the world and supported him whilst he

myopically focused on his research; and to our children Thomas, Amelia and Edward who always wanted an update of how 'daddy' is getting on.

Finally and not least to 'Penny' the British bulldog who to quote my Australian friends "always put a smile on my dial" when I returned to the UK, and to my father and mother who never lost faith and always encouraged their son to strive for success. To them I dedicate this PhD.

Andrew Stephen King  
Hobart, Australia & St Andrews, Great Britain  
August 2015



## ABSTRACT

Globally, Atlantic salmon aquaculture is faced with a critical challenge: How best to deliver long-term sustainable growth, whilst optimising the opportunity for the expansion of the industry presented by an increasing global seafood demand?

This thesis presents a novel framework of complementary decision support approaches to enable decision-makers to better understand the factors influencing aquaculture development, and examine alternative production (growout) technologies that more effectively address the challenges associated with intensification and expansion. The framework was developed through a combination of fieldwork (international data-gathering), key stakeholder discussions, and the application of targeted qualitative and quantitative analytical approaches; using the Tasmanian industry as a Case Study. The initial research focused on shorter-term (tactical) decision support. A situational analysis defined the business environment, and appraised viable expansion options (offshore, closed-containment and extractive bio-remediation). An economic analysis of selected options then provided a comparison of financial performance and risk. The outputs of this initial component next informed strategic decision-making approaches; employing scenario analysis to explore plausible strategies for the adoption of land-based recirculating aquaculture systems; and qualitative modelling to understand the causal dynamics driving and regulating the industry, and their impact on technology selection.

Whilst it was clear that business economic viability is paramount, the results suggested that societal acceptance (the Social License to operate) is playing an increasingly important role in influencing business decisions. There is no single 'right' technological solution; social acceptance, in particular considerations regarding human wellbeing, trust, and animal welfare concerns, will shape the business environment and therefore technology selection. The research emphasised the importance of employing a balance of tactical and strategic decision-making techniques, and of engaging with a broad range of industry stakeholders. It also highlighted the complexity and dynamic nature of the industry and that key variances (economic, regional, strategic, technological, and temporal) must be included in decision-making.

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## LIST OF ABBREVIATIONS

AGD	Amoebic Gill Disease
ASC	Aquaculture Stewardship Council
CAGR	Compound Average Growth Rate
CAPEX	Capital Expenditure
CPM	Competitive Profile Matrix
CRC	Australian Seafood Cooperative Research Centre
COP	Cost Of Production
DCF	Discounted Cash Flow
DFO	Department of Fisheries & Oceans, Canada
DPIPWE	Department of Primary Industries, Parks, Water and Environment, Tasmania
EBIT	Earnings Before Interest and Tax
EIS	Environmental Impact Statement
ENGO	Environmental Non Governmental Organisation
FAO	Food and Agricultural Organisation
FCC	Floating Closed Containment
FCR <sub>b</sub>	Biological Feed Conversion Ratio
FCR <sub>e</sub>	Economic Feed Conversion Ratio
FRDC	Fisheries Research and Development Corporation, Australia
FRP	Fibre Reinforced Plastic
FTE	Full Time Equivalent
HOG	Head On Gutted
H <sub>s</sub>	Significant Wave Height (mean wave height, trough to crest of the highest 1/3 of the waves)
ISFA	International Salmon Farmers Association
IMTA	Integrated Multi Trophic Aquaculture



IRR	Internal Rate of Return
NPV	Net Present Value
OPEX	Operational Expenditure
PESTEL	Political, Economic, Social, Technological, Environmental and Legal
RAS	Recirculating Aquaculture System(s)
ROE	Return On Equity
ROI	Return On Investment
ROW	Rest Of the World
SBP	Selective Breeding Programme
SEPA	Scottish Environmental Protection Agency
SME	Subject Matter Expert
SOPs	Standard Operating Procedures
SSPO	Scottish Salmon Producers Organisation
SWOT	Strengths, Weaknesses, Opportunities and Threats
TGC	Thermal Growth Coefficient
TSGA	Tasmanian Salmonid Growers Association